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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

07 MAR 2005

(PCT Article 36 and Rule 70)

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This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

This REPORT consists of a total of 3 sheets, including this cover sheet.

[X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 13 sheet(s).

. This report contains indications relating to the following items:

I	[X]	Basis of the report
II	[ ]	Priority
III	[ ]	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	[ ]	Lack of unity of invention
V	[X]	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	[ ]	Certain documents cited
VII	[ ]	Certain defects in the international application
VIII	[ ]	Certain observations on the international application

Date of submission of the demand 6 April 2004	Date of completion of the report 5 November 2004
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer ASANKA PERERA Telephone No. (02) 6283 2373

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU2003/001144

Basis of the report

1. With regard to the elements of the international application:*

[ ] the international application as originally filed.

[X] the description, pages **1, 2, 10-28,** as originally filed,
pages , filed with the demand,
pages **3-9,** received on **13 September 2004** with the letter of **7 September 2004**

[X] the claims, pages , as originally filed,
pages , as amended (together with any statement) under Article 19,
pages , filed with the demand,
pages **29-34,** received on **13 September 2004** with the letter of **7 September 2004**

[X] the drawings, pages **1/14-14/14,** as originally filed,
pages , filed with the demand,
pages , received on with the letter of

[ ] the sequence listing part of the description:
pages , as originally filed
pages , filed with the demand
pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/fig.

5. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Statement

Novelty (N)	Claims 1-31	YES
	Claims	NO
Inventive step (IS)	Claims 1-31	YES
	Claims	NO
Industrial applicability (IA)	Claims 1-31	YES
	Claims	NO

Citations and explanations (Rule 70.7)

The cited prior art documents do not disclose or fairly suggest thermodynamic cycles as defined by claim 1 or 2, nor methods of generating power from a thermodynamic cycle as defined by claim 20 or 21.

Therefore the subject matter of these claims is new and meets the requirements of Article 33(2) PCT with regard to novelty.

The claimed invention is not obvious in the light of any of the cited documents nor is it disclosed in any obvious combination of them. It is also considered that it would not be obvious to a person skilled in the art in the light of common general knowledge either by itself or in combination with any of these documents.

Therefore the subject matter of these claims is not obvious and meets the requirements of Article 33(3) PCT with regard to inventive step.

OBJECT OF THE INVENTION

It is an object of a preferred embodiment of the invention to provide apparatus for a heat pump and/or a heat pump which will increase the utilization of available energy in such apparatus at present.

It is an alternative object of a preferred embodiment of the invention to provide a method of controlling a heat pump which will increase the efficiency of such apparatus at present.

It is an alternative object of a preferred embodiment of the invention to provide a method of controlling a turbine and generator which will increase the efficiency of such apparatus at present.

It is a further alternative object of a preferred embodiment of the invention to provide a turbine and/or a method of communicating a fluid to a turbine which will increase the utilization of available energy from such fluid at present.

It is a still further alternative object to at least provide the public with a useful choice.

Other objects of the present invention may become apparent from the following description, which is given by way of example only.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor.

According to a second aspect of the present invention, there is provided a thermodynamic cycle including a compressor, a condenser

downstream of the compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine and a second turbine downstream of the evaporator and upstream of the compressor.

Preferably, the thermodynamic cycle further includes a heat exchanger located between said first turbine and said evaporator, the heat exchanger operable to reject heat to another thermodynamic cycle.

Preferably, at least one of the first turbine and second turbine includes:
a rotor chamber;
a rotor rotatable about a central axis within said rotor chamber;
at least one nozzle including a nozzle exit for applying a fluid a fluid supply in the thermodynamic cycle to said rotor to thereby drive said rotor and generate power;
at least one exhaust aperture to, in use, exhaust said fluid from said turbine;
wherein the flow of said fluid from said at least one nozzle exit is periodically interrupted by at least one flow interrupter means, thereby raising the pressure of said fluid inside said at least one nozzle.

Preferably, the at least one of the first turbine and second turbine includes at least one fluid storage means between said fluid supply and said at least one nozzle.

Preferably, the fluid storage means has a capacity at least equal to a displacement of the compressor.

Preferably, the at least one flow interrupter means substantially stops the flow of said fluid from said at least one nozzle exit until the pressure inside said at least one nozzle rises to a preselected minimum pressure, which is less than or equal to the pressure of the fluid supply.

Preferably, in use, the flow of said fluid from said at least one nozzle is interrupted by said at least one interrupter means for a period sufficient to bring said fluid immediately upstream of said at least one outer nozzle substantially to rest.

Preferably, the rotor has a plurality of channels shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle enters said channels.

Preferably, the rotor is has a plurality of blades shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle contacts said blades.

Preferably, the at least one flow interrupter means includes at least one vane connectable to and moveable with an outer periphery of said rotor and adapted to interrupt the flow of said fluid out of said at least one outer nozzle exit when said at least one vane is substantially adjacent said at least one nozzle exit.

Preferably, the flow interrupter means includes a plurality of said vanes substantially evenly spaced apart around said outer periphery of said rotor.

Preferably, the at least one nozzle in use supplies said fluid to said rotor at a sonic or supersonic velocity.

Preferably, the at least one exhaust aperture includes diffuser and expander sections to decrease the velocity of said fluid and maintain the pressure of the fluid flow once it has decelerated to a subsonic velocity.

Preferably, at least one of the first and second turbines includes a rotor including two or more spaced apart rotor windings and a stator including a plurality of stator windings about said rotor, wherein at least two of said stator windings are connected to a controllable current source, each controllable current source operable to energise the stator windings to which it is connected.

Preferably, each controllable current source is operable to energise the stator windings to which it is connected after the rotor has reached a predetermined velocity.

Preferably, the predetermined velocity is the terminal velocity for the current operating conditions of the turbine.

Preferably, each current source increases or decreases the current through their respective stator windings dependent on a measure of the power output from the stator windings.

According to another aspect of the present invention, there is provided a method of control for the thermodynamic cycle described in the immediately preceding four paragraphs including repeatedly measuring the power output from the stator windings and increasing the current through the windings if the current measure of power output is greater than a previous measure of power output and decreasing the current through the windings if the current measure of power output is less than a previous measure of power output.

According to another aspect of the present invention, there is provided a method of generating power from a thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor, wherein the first second turbines include a rotor and at least one nozzle to apply fluid to the rotor to thereby drive said rotor and generate power;
the method including providing at least one flow interrupter means to periodically interrupt the flow of said fluid out of said at least one nozzle, thereby raising the pressure of said fluid inside said at least one nozzle to a preselected minimum pressure which is less or equal to said fluid supply means pressure before resuming the flow of said fluid out of said at least one nozzle.

According to another aspect of the present invention, there is provided a method of generating power from a thermodynamic cycle including a compressor, a condenser downstream of the compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine

and a second turbine downstream of the evaporator and upstream of the compressor wherein the first second turbines include a rotor and at least one nozzle to apply fluid to the rotor to thereby drive said rotor and generate power; the method including providing at least one flow interrupter means to periodically interrupt the flow of said fluid out of said at least one nozzle, thereby raising the pressure of said fluid inside said at least one nozzle to a preselected minimum pressure which is less or equal to said fluid supply means pressure before resuming the flow of said fluid out of said at least one nozzle.

Preferably, the preselected minimum pressure is sufficient to cause the fluid to reach the local sonic velocity at a throat of the nozzle.

Preferably, the method includes accelerating fluid exiting said at least one nozzle to supersonic velocities.

A control system for the thermodynamic cycle described in the preceding paragraphs, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
control means for the compressor, wherein the control means is in communication with said sensing means to receive as inputs said measure of an output of the thermodynamic cycle and a measure of the work input of the compressor;
wherein the control means is operable to compute a measure of efficiency from said inputs and vary the speed of the compressor to maximise said measure of efficiency or to maintain said measure of efficiency at a predetermined level.

Preferably, the control system further includes second control means for the second turbine and sensing means for providing a measure of the temperature of a controlled area, wherein the second control means receives as a further input said measure of the temperature of a controlled area, and is operable to open or close the fluid flow path through said second turbine in

response to sensed variations in temperature in the controlled area in relation to a target measure.

Preferably, the second control means further receives as an input a measure indicative of the amount of refrigerant in the cycle which is vaporised after an evaporation phase in the cycle and to open or close the fluid flow path through said second turbine to maintain vaporised refrigerant after the evaporation phase.

Preferably, the operation of the second control means to maintain vaporised refrigerant after the evaporation phase is performed after a predetermined delay from the control means opening or closing the fluid flow path through said second turbine in response to said sensed variations of temperature.

Preferably, the control system includes third control means for a condenser in the thermodynamic cycle, the control system varying the operation of the condenser to maintain a required level of cooling of refrigerant by the condenser.

Preferably, the control means, second control means and third control means is a single microcontroller or microprocessor or a plurality of microcontrollers or microprocessors with at least selected microcontrollers or microprocessors in communication with each other to allow management of the timing of the functions of the control system.

A control system for the thermodynamic cycle described in the preceding paragraphs, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
control means for the compressor, wherein the control means is in communication with said sensing means to receive as inputs said measure of an output of the thermodynamic cycle and a measure of the work input of the compressor;
wherein the control means is operable to compute a measure of efficiency

from said inputs and vary the speed of the compressor to maximise said measure of efficiency or to maintain said measure of efficiency at a predetermined level and wherein the control system is operable to control the direct current through the stator windings of said turbine.

Preferably, the control system is operable control the direct current through the stator windings to dynamically maintain the balance of said turbine when loaded.

Further aspects of the present invention, which should be considered in all its novel aspects, will become apparent from the following description, given by way of example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1: Shows a prior art thermodynamic cycle.

Figure 2: Shows a first thermodynamic cycle according to an aspect of the present invention.

Figure 3: Shows a second thermodynamic cycle according to an aspect of the present invention.

Figure 4: Shows a cross-sectional view of a first turbine according to an aspect of the present invention.

Figure 5: Shows a cross-sectional view of a second turbine according to an aspect of the present invention.

Figure 6: Shows an enlarged view of a channel of the turbine of Figure 5.

Figure 7: Shows a third thermodynamic cycle illustrating a control system according to an aspect of the present invention.

Figures 8 – 10, 12: Show flow charts of a method of controlling a thermodynamic cycle according to aspects of the present invention.

Figure 11: Shows a diagram of a generator according to an aspect of the present invention.

Figure 13: Shows a flow chart of an initialisation subroutine for the control system.

Figure 14: Shows a flow chart of a scheduling subroutine for the control system.

CLAIMS

1. A thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor.

2. A thermodynamic cycle including a compressor, a condenser downstream of the compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine and a second turbine downstream of the evaporator and upstream of the compressor.

3. The thermodynamic cycle of claim 2 further including a heat exchanger located between said first turbine and said evaporator, the heat exchanger operable to reject heat to another thermodynamic cycle.

4. The thermodynamic cycle of any one of claims 1 to 3, wherein at least one of the first turbine and second turbine includes:
a rotor chamber;
a rotor rotatable about a central axis within said rotor chamber;
at least one nozzle including a nozzle exit for applying a fluid a fluid supply in the thermodynamic cycle to said rotor to thereby drive said rotor and generate power;
at least one exhaust aperture to, in use, exhaust said fluid from said turbine;
wherein the flow of said fluid from said at least one nozzle exit is periodically interrupted by at least one flow interrupter means, thereby raising the pressure of said fluid inside said at least one nozzle.

5. The thermodynamic cycle of claim 4, wherein the at least one of the first turbine and second turbine includes at least one fluid storage means between said fluid supply and said at least one nozzle.

6. The thermodynamic cycle of claim 5, wherein said fluid storage means has a capacity at least equal to a displacement of the compressor.

7. The thermodynamic cycle of any one of claims 4 to 6, wherein said at least one flow interrupter means substantially stops the flow of said fluid from said at least one nozzle exit until the pressure inside said at least one nozzle rises to a preselected minimum pressure, which is less than or equal to the pressure of the fluid supply.

8. The thermodynamic cycle of any one of claims 4 to 7, wherein in use, said flow of said fluid from said at least one nozzle is interrupted by said at least one interrupter means for a period sufficient to bring said fluid immediately upstream of said at least one outer nozzle substantially to rest.

9. The thermodynamic cycle of any one of claims 4 to 8, wherein said rotor has a plurality of channels shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle enters said channels..

10. The thermodynamic cycle of any one of claims 4 to 9, wherein said rotor is has a plurality of blades shaped, positioned and dimensioned to provide a turning moment about said central axis when refrigerant from said at least one nozzle contacts said blades.

11. The thermodynamic cycle of any one of claims 4 to 10, wherein said at least one flow interrupter means includes at least one vane connectable to and moveable with an outer periphery of said rotor and adapted to interrupt the flow of said fluid out of said at least one outer nozzle exit when said at least one vane is substantially adjacent said at least one nozzle exit.

12. The thermodynamic cycle of claim 11, wherein said flow interrupter means includes a plurality of said vanes substantially evenly spaced apart around said outer periphery of said rotor.

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13. The turbine of any one of claims 4 to 12, wherein said at least one nozzle in use supplies said fluid to said rotor at a sonic or supersonic velocity.

14. The thermodynamic cycle of claim 13, wherein said at least one exhaust aperture includes diffuser and expander sections to decrease the velocity of said fluid and maintain the pressure of the fluid flow once it has decelerated to a subsonic velocity.

15. The thermodynamic cycle of any one of claims 1 to 14, wherein at least one of the first and second turbines includes a rotor including two or more spaced apart rotor windings and a stator including a plurality of stator windings about said rotor, wherein at least two of said stator windings are connected to a controllable current source, each controllable current source operable to energise the stator windings to which it is connected.

16. The thermodynamic cycle of claim 15, wherein each controllable current source is operable to energise the stator windings to which it is connected after the rotor has reached a predetermined velocity.

17. The thermodynamic cycle of claim 16, wherein the predetermined velocity is the terminal velocity for the current operating conditions of the turbine.

18. The thermodynamic cycle of any one of claims 15 to 17, wherein each current source increases or decreases the current through their respective stator windings dependent on a measure of the power output from the stator windings.

19. A method of control for the thermodynamic cycle claimed in any one of claims 15 to 18 including repeatedly measuring the power output from the stator windings and increasing the current through the windings if the current measure of power output is greater than a previous measure of power output and decreasing the current through the windings if the current measure of power output is less than a previous measure of power output.

20. A method of generating power from a thermodynamic cycle including a compressor, a first turbine downstream of the compressor, a heat exchanger located downstream of the first turbine and operable to reject heat from the cycle to another thermodynamic cycle, an evaporator downstream of the heat exchanger and a second turbine downstream of the evaporator and upstream of the compressor, wherein the first second turbines include a rotor and at least one nozzle to apply fluid to the rotor to thereby drive said rotor and generate power;
the method including providing at least one flow interrupter means to periodically interrupt the flow of said fluid out of said at least one nozzle, thereby raising the pressure of said fluid inside said at least one nozzle to a preselected minimum pressure which is less or equal to said fluid supply means pressure before resuming the flow of said fluid out of said at least one nozzle.

21. A method of generating power from a thermodynamic cycle including a compressor, a condenser downstream of the compressor, a first turbine downstream of the condenser, an evaporator downstream of the first turbine and a second turbine downstream of the evaporator and upstream of the compressor wherein the first second turbines include a rotor and at least one nozzle to apply fluid to the rotor to thereby drive said rotor and generate power;
the method including providing at least one flow interrupter means to periodically interrupt the flow of said fluid out of said at least one nozzle, thereby raising the pressure of said fluid inside said at least one nozzle to a preselected minimum pressure which is less or equal to said fluid supply means pressure before resuming the flow of said fluid out of said at least one nozzle.

22. The method of claim 20 or claim 21, wherein said preselected minimum pressure is sufficient to cause the fluid to reach the local sonic velocity at a throat of the nozzle.

23. The method of claim 22, including accelerating fluid exiting said at least

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one nozzle to supersonic velocities.

24. A control system for the thermodynamic cycle claimed in any one of claims 1 to 18, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
control means for the compressor, wherein the control means is in communication with said sensing means to receive as inputs said measure of an output of the thermodynamic cycle and a measure of the work input of the compressor;
wherein the control means is operable to compute a measure of efficiency from said inputs and vary the speed of the compressor to maximise said measure of efficiency or to maintain said measure of efficiency at a predetermined level.

25. The control system of claim 24, further including second control means for the second turbine and sensing means for providing a measure of the temperature of a controlled area, wherein the second control means receives as a further input said measure of the temperature of a controlled area, and is operable to open or close the fluid flow path through said second turbine in response to sensed variations in temperature in the controlled area in relation to a target measure.

26. The control system of claim 24 or claim 25, wherein the second control means further receives as an input a measure indicative of the amount of refrigerant in the cycle which is vaporised after an evaporation phase in the cycle and to open or close the fluid flow path through said second turbine to maintain vaporised refrigerant after the evaporation phase.

27. The control system of any one of claims 24 to 26, wherein the operation of the second control means to maintain vaporised refrigerant after the evaporation phase is performed after a predetermined delay from the control means opening or closing the fluid flow path through said second turbine in response to said sensed variations of temperature.

28. The control system of any one of claims 24 to 27 including third control means for a condenser in the thermodynamic cycle, the control system varying the operation of the condenser to maintain a required level of cooling of refrigerant by the condenser.

29. The control system of claim 28, wherein the control means, second control means and third control means is a single microcontroller or microprocessor or a plurality of microcontrollers or microprocessors with at least selected microcontrollers or microprocessors in communication with each other to allow management of the timing of the functions of the control system.

30. A control system for the thermodynamic cycle claimed in any one of claims 15 to 17, the control system including:
sensing means for providing a measure of an output of the thermodynamic cycle;
control means for the compressor, wherein the control means is in communication with said sensing means to receive as inputs said measure of an output of the thermodynamic cycle and a measure of the work input of the compressor;
wherein the control means is operable to compute a measure of efficiency from said inputs and vary the speed of the compressor to maximise said measure of efficiency or to maintain said measure of efficiency at a predetermined level and wherein the control system is operable to control the direct current through the stator windings of said turbine.

31. The control system of claim 30, operable control the direct current through the stator windings to dynamically maintain the balance of said turbine when loaded.